CLAIMS

1. A sensor assembly for use in a patient breathing system for providing real-time optical absorption analysis ~~of the NO_2 content of a~~ breathing gas sample and providing real time analysis of the NO content of the breathing gas sample, said sensor assembly comprising:

a semiconductor radiation source emitting radiation having a emission spectrum with a maximum wavelength of about 600 nm, the radiation source being operated at a sampling frequency of at least about 10 Hz;

a sample chamber having an inlet conduit for supplying a gas flow including the breathing gas sample, the NO_2 content of which is to be measured, to the chamber, the radiation from said radiation source passing through the gas in said sample chamber, said sample chamber having an outlet conduit for passing the gas flow from said sample chamber;

a detector for receiving the radiation passed through the breathing gas sample in said sample chamber and for providing an output signal indicative of the NO_2 content of the breathing gas sample in said sample chamber, the detector providing the output signal in a response time of about 200 ms, such that the sensor assembly provides the output signal in real-time; and

an NO gas sensor coupled to said outlet conduit for providing a real time measurement of the NO content of the breathing gas sample.

2. A sensor assembly according to claim 1 wherein said semiconductor radiation source is further defined as emitting radiation having an emission spectrum with a maximum wavelength of about 520 nm.

3. A sensor assembly according to claim 1 wherein said semiconductor radiation source emits radiation in an emission spectrum between about 380 - 520 nm.

4. A sensor assembly according to claim 1 wherein said semiconductor radiation source comprises a light emitting diode.

5. A sensor assembly according to claim 1 wherein said semiconductor radiation source comprises a laser diode.

6. A sensor assembly according to claim 1 further including a further detector for detecting the emitted radiation of said radiation source, said further detector being connected to a power supply for said radiation source for stabilizing the operation of said radiation source.

7. A sensor assembly according to claim 1 wherein said detector comprises a silicon detector.

8. A sensor assembly according to claim 1 wherein said detector comprises a blue enhanced type of detector.

9. A sensor assembly according to claim 1 wherein said detector is coupled to an output signal amplifier.

10. A sensor assembly according to claim 9 wherein said output signal amplifier is a narrow bandwidth amplifier, the bandwidth of which is centered at said sampling frequency.

11. A sensor assembly according to claim 1 further including an optical filter interposed in front of said detector along a path of the emitted radiation in said sensor.

12. A sensor assembly according to claim 11 wherein said optical filter passes a spectral band centered on a maximum of the emission spectrum of said radiation source.

13. A sensor assembly according to claim 1 further including a reference detector for detecting the radiation passed through the gas sample in said sample chamber

and for compensating said first mentioned detector.

14. A sensor assembly according to claim 13 wherein said reference detector includes means for reducing the sensitivity of said reference detector to spectral absorption resulting from the presence of NO_2 in the gas sample.

15. A sensor assembly according to claim 14 wherein said reducing means comprises means for causing a different spectral region of said emission spectrum to be applied to said reference detector than the spectral region of said emission spectrum applied to said first mentioned detector.

16. A sensor assembly according to claim 15 wherein said means applying different spectral regions of said emission spectrum to said first mentioned detector and said to reference detector comprises a dichroic beam splitter interposed in a path of the radiation exiting said sample chamber for applying beams of different spectral regions to said first mentioned detector and said reference detector.

17. A sensor assembly according to claim 15 wherein said means applying different spectral regions of said emission spectrum to said first mentioned detector and to said reference detector comprises filters interposed in front of said first mentioned detector and said reference detector, said filters passing different spectral regions of said emission spectrum to said first mentioned detector and said reference detector.

18. A sensor assembly according to claim 13 wherein said radiation source emits radiation in a further emission spectrum and wherein said reference detector detects radiation in said further emission spectrum.

19. A sensor assembly according to claim 1 further including means having a pair of filters, said filters passing different spectral regions of said emission spectrum and means for placing one or the other of said filters in front of said detector

along a path of the radiation in said sensor for providing compensation to said detector.

20. A sensor assembly according to claim 1 further including a temperature sensor for sensing the temperature of the gas sample in said sampling chamber and means for compensating the output signal of said detector in accordance with the sensed temperature of the gas sample.

21. A sensor assembly according to claim 20 wherein said sample chamber has a heater operatively associated therewith.

22. A sensor assembly according to claim 1 wherein the sampling frequency of said radiation source is in the kHz range.

23. A sensor assembly according to claim 1 wherein said NO gas sensor comprises a chemiluminescent sensor.

24. A sensor assembly according to claim 1 wherein said NO gas sensor includes an electrochemical cell.

25. A sensor assembly for use in a patient breathing system for providing optical absorption analysis of the NO_2 content of a breathing gas sample, said sensor assembly comprising:

a first semiconductor radiation source emitting radiation having a emission spectrum with a maximum wavelength of about 600 nm;

a sample chamber containing the breathing gas sample, the NO_2 content of which is to be measured, the radiation from said first radiation source passing through the gas in said sample chamber;

a detector for receiving radiation passed through the breathing gas sample in said sample chamber;

a second semiconductor radiation source providing radiation for passage through said sample chamber for receipt by said detector, the wavelength of the radiation

provided by said second radiation source being such as to minimize absorption of the radiation by nitrogen dioxide, said first and second radiation sources being alternately energized at a sampling frequency;

said detector providing an output signal formed by the alternative energization of said radiation sources indicative of the NO_2 content of the breathing gas sample in said sample chamber.

26. A sensor assembly according to claim 25 wherein said first semiconductor radiation source is further defined as emitting radiation having an emission spectrum with a maximum wavelength of about 520 nm.

27. A sensor assembly according to claim 25 wherein said first semiconductor radiation source emits radiation in an emission spectrum between about 380 - 520 nm.

28. A sensor assembly according to claim 25 wherein at least one of said first and second semiconductor radiation sources comprises a light emitting diode.

29. A sensor assembly according to claim 25 wherein at least one of said first and second said semiconductor radiation sources comprises a laser diode.

30. A sensor assembly according to claim 25 further including a further detector for detecting the emitted radiation of at least one of said radiation sources, said further detector being connected to a power supply for said radiation source for stabilizing the operation of said at least one radiation source.

31. A sensor assembly according to claim 25 wherein said detector comprises a silicon detector.

32. A sensor assembly according to claim 25 wherein said detector comprises a blue enhanced type of detector.

33. A sensor assembly according to claim 25 wherein said detector is coupled to an output signal amplifier.

34. A sensor assembly according to claim 33 further including an AC coupling for said amplifier for removing DC components.

35. A sensor assembly according to claim 33 wherein said output signal amplifier is a narrow bandwidth amplifier, the bandwidth of which is centered at said sampling frequency.

36. A sensor assembly according to claim 25 further including a filter interposed in front of said detector along a path of the emitted radiation in said sensor.

37. A sensor assembly according to claim 25 further including a temperature sensor for sensing the temperature of the gas sample in said sampling chamber and means for compensating the output signal of said detector in accordance with the sensed temperature of the gas sample.

38. A sensor assembly according to claim 37 wherein said sample chamber has a heater operatively associated therewith.

39. A sensor assembly according to claim 25 wherein each of said radiation sources is energized at a sampling frequency of at least about 10 Hz.

40. A sensor assembly according to claim 39 wherein each of said radiation sources is energized at a sampling frequency in the kHz range.

41. A sensor assembly according to claim 25 further including an NO gas sensor operatively associated therewith.

42. A method for determining the real-time NO_2 and NO content of a breathing gas sample in a patient breathing system comprising the steps of:

providing a flow of breathing gas through a sample chamber, the flow including the breathing gas sample;

passing radiation from a semiconductor radiation source through the gas sample in the sample chamber, said radiation having an emission spectrum with a maximum wavelength of about 600 nm;

operating the radiation source at a sampling frequency of at least about 10 Hz;

sensing the radiation exiting the gas sample;

determining the NO_2 content of the gas sample from the optical spectral absorption characteristics of the sensed radiation resulting from the presence and amount of NO_2 in the gas sample in a response time of about 200 ms such that the NO_2 content of the gas sample can be determined in real-time; and

passing breathing gas discharged from the sample chamber through an NO gas sensor providing real time measurement of the NO content of the gas sample.

43. The method according to claim 42 further defined as passing radiation having an emission spectrum with a maximum wavelength of about 520 nm through the gas sample.

44. The method according to claim 42 further defined as passing radiation having an emission spectrum with wavelengths in a range of about 380 - 520 nm through the gas sample.

45. The method according to claim 42 further defined as passing radiation from a light emitting diode radiation source through the gas sample.

46. The method according to claim 42 further defined as passing radiation from a laser diode through the gas sample.

47. The method according to claim 42 further including the step of carrying out a further sensing of the radiation exiting the gas sample and using the results of said further sensing to provide compensation to said first mentioned sensing.

48. The method according to claim 47 wherein said further sensing is carried out under conditions of reduced sensitivity to spectral absorption resulting from the presence of NO_2 in the gas sample.

49. The method according to claim 47 wherein said further sensing is carried out using a different spectral region of the emission spectrum than is employed in said first mentioned sensing.

50. The method according to claim 48 wherein said further sensing is carried out using a different emission spectrum than is used in said first mentioned sensing.

51. The method according to claim 42 further defined as sensing the temperature of the gas sample and compensating the sensing results of said sensing step.

52. The method according to claim 51 further defined as heating the gas sample.

53. The method according to claim 42 further defined as passing the breathing gas discharged from the sample chamber through a chemiluminescent NO gas sensor.

54. The method according to claim 42 further defined as passing the breathing gas discharged from the sample chamber through an electrochemical cell.

55. The method according to claim 42 further defined as operating the radiation source at a sampling frequency in the kHz range.

56. A method for determining the NO_2 content of a breathing gas sample in a patient breathing system comprising the steps of:

providing a breathing gas sample;

passing radiation from a first semiconductor radiation source through the gas sample in the sample chamber, said radiation from said first source having an emission spectrum with a maximum wavelength of about 600 nm;

passing radiation from a second radiation source through the gas sample in the sample chamber, the wavelength of the radiation from said second source being such as to minimize absorption of the radiation by nitrogen dioxide;

the first and second radiation sources being operated at a selected sampling frequency;

sensing the radiation exiting the gas sample as a result of the alternative operation of the radiation sources; and

determining the NO_2 content of the gas sample from the sensed exiting radiation.

57. The method according to claim 56 further defined as passing radiation from said first source having an emission spectrum with a maximum wavelength of about 520 nm.

58. The method according to claim 56 further defined as passing radiation from said first source having an emission spectrum with wavelengths in a range of about 380 - 520 nm.

59. The method according to claim 56 further defined as passing radiation from a light emitting diode radiation source through the gas sample.

60. The method according to claim 56 further defined as passing radiation from a laser diode through the gas sample.

61. The method according to claim 56 further defined as sensing the

temperature of the gas sample and compensating the sensing results of said sensing step.

62. The method according to claim 61 further defined as heating the gas sample.

63. The method according to claim 56 further defined as operating each of the first and second radiation sources at a sampling frequency of at least about 10 Hz.

64. The method according to claim 48 further defined as operating the first and second radiation sources at a sampling frequency in the kHz range.

65. The method according to claim 56 further including the step of measuring the NO content of the breathing gas.